CIE-MAP

Centre for Industrial Energy, Materials and Products

Saving Energy through Resource Efficiency

Main findings

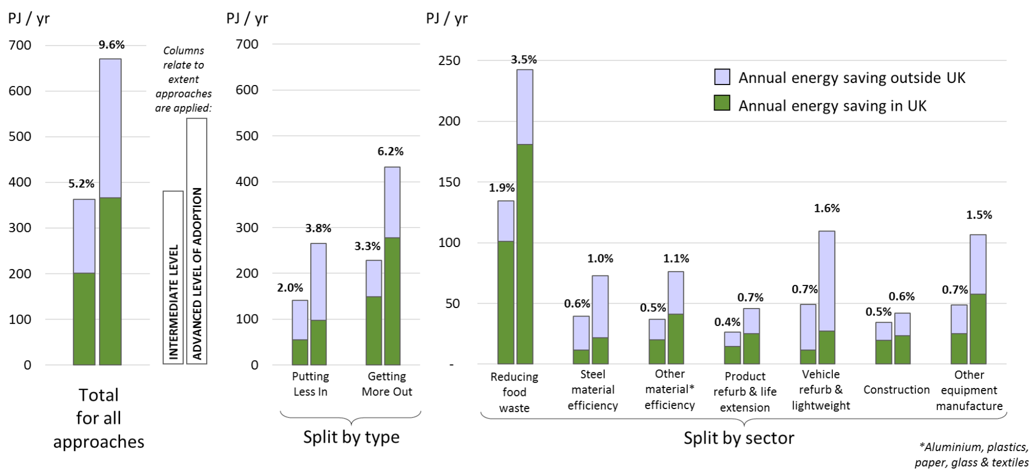
- Resource efficiency has similar overall potential to save energy as industrial energy efficiency approaches.
- There is a huge range of opportunities to improve resource efficiency.
- The energy saving scopes of resource efficiency and energy efficiency complement each other.
- Firstly “getting more out” of products, and then “putting less in” to them, maximises value capture and energy savings.
- Significant additional potential energy savings are outside the scope of energy efficiency or traditional resource efficiency approaches.

Scope for energy savings

Producing goods and delivering services uses energy. Both directly but also indirectly in order to create the intermediate products that are required as inputs. The direct use of energy can be targeted though energy efficiency measures but it is also possible to reduce overall demand for energy by resource efficiency measures that reduce the need for goods and services. Some resource efficiency approaches improve value chain collaboration between businesses while others ensure that the needs of consumers are met with less resources. Analysis of many recognised resource efficiency approaches has demonstrated that resource efficiency has similar overall potential to save energy as industrial energy efficiency approaches[i]. If we want to save energy then we should pay equal attention to these approaches.

Figure 1.

Energy savings possible through resource efficiency



Percentages refer to **global** reduction in energy use due to circular economy approaches applied in the **UK**, as a proportion of **UK** industrial energy use (in 2007)

Note that the sum of savings for approaches split by type or sector is greater than the total savings for all approaches as some approaches affect the same energy use

Energy analysis

Energy efficiency options have been identified with opportunity to achieve significant energy demand reduction[iii]. However, some processes that are already relatively energy efficient have less scope for improvement. In many cases, it is these processes that are affected by resource efficiency approaches. That is, in general, the energy saving scopes of resource efficiency and energy efficiency complement each other.

Different sectors exhibit significantly different distributions of energy use between direct energy use and energy use "embodied" in inputs[iv]. For example, the direct energy use of the steel sector is very high, while the energy embodied in its inputs is less significant. Energy efficiency and approaches that either reduce yield losses within the steel sector or increase the utility of the steel that it supplies have greater scope to save energy than approaches that reduce the level of its inputs. By contrast, the construction sector has much lower direct energy use but requires materials that embody significant energy use. Approaches that allow the construction sector to make better use of these materials therefore have greater scope to save energy than energy efficiency alone.

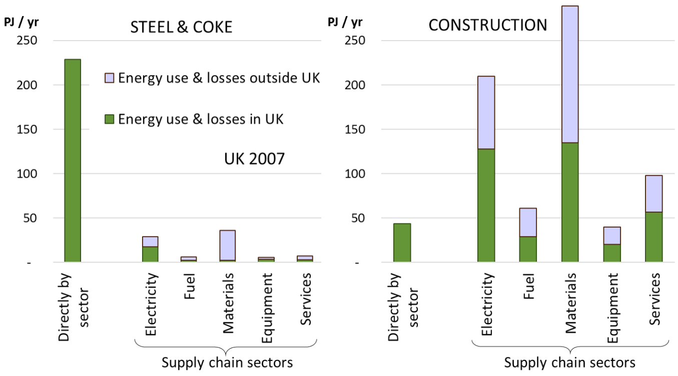


Figure 2. Energy use due to steel and construction subsectors

The scope for sectors to achieve energy savings through a given improvement in resource efficiency is often greater when this improvement is applied to its products rather than individual inputs. In general, value chain collaborations should focus on firstly "getting more out" of their products, and then "putting less in" to them, to maximise value capture and energy savings. For example, all else being equal, a car manufacturer that can capture the value of increasing the intensity with which its vehicles are used by 10% will be in a stronger competitive position and will save more energy than a car manufacturer that reduces its demand for materials by 10%[v]. Of course, the options are not mutually exclusive and the full range of resource efficiency and energy efficiency opportunities should be considered by each industry.

Putting less in and getting more out

There is a huge range of opportunities to improve resource efficiency[ii] that are suited to each sector and product type and that can be applied at each stage of products lifecycles. It may be helpful to think of them as either putting less resources in (by wasting less) or getting more out (by making better use of products). They are the means by which a more circular economy might be achieved:

Putting less in

Reducing material content of products: optimised designs, stronger materials.

Reducing losses of materials: improved manufacturing processes, better material production yields.

Enhanced recycling: more careful selection of materials.

Getting more out

More intensive use: sharing schemes, better optimisation of use.

Improved longevity: encouraging continued use, design for durability.

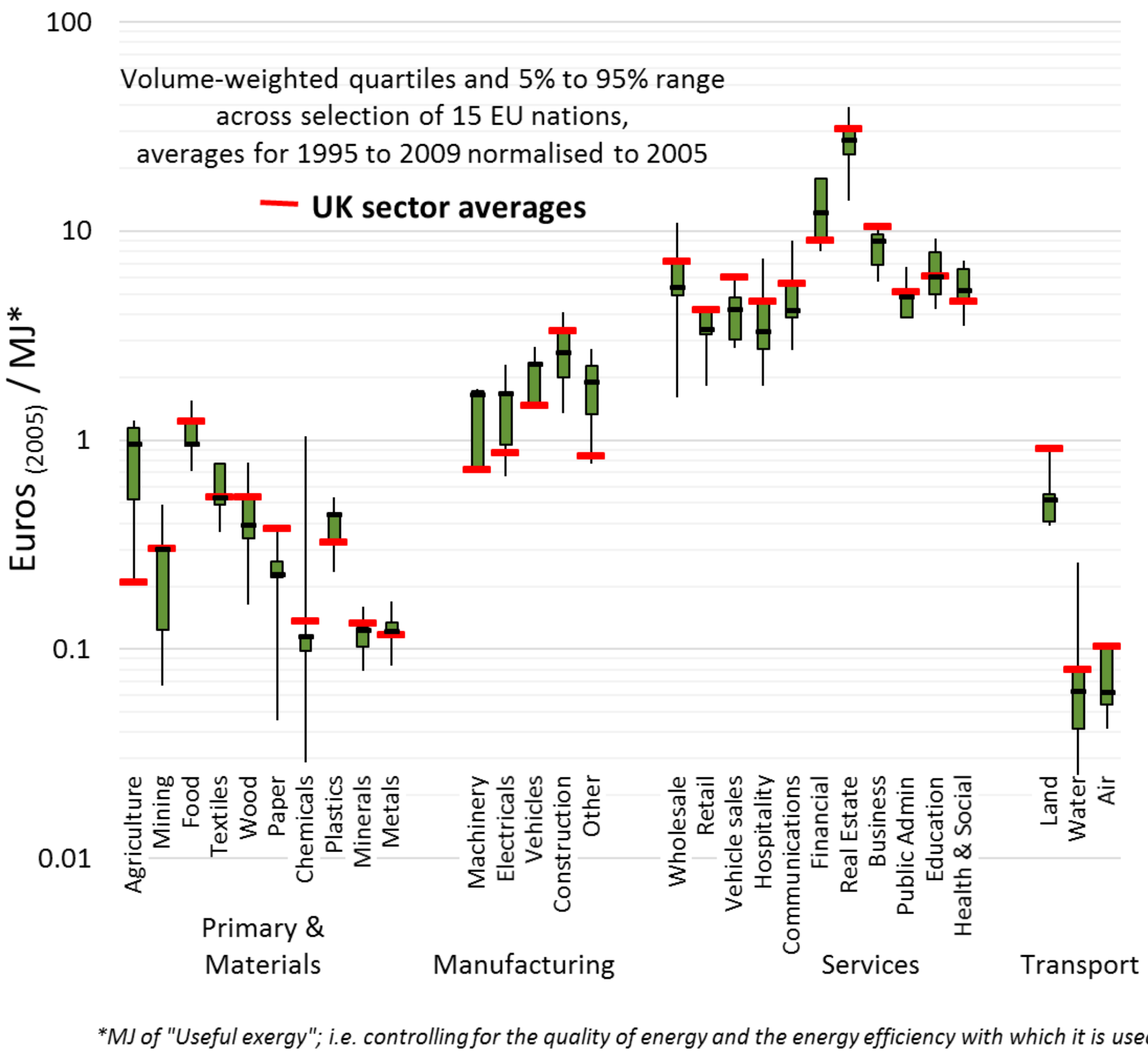
Life extension: reuse of products, refurbishment, retrofit of buildings, reuse of components.

Energy savings beyond efficiency

The variation in the economic value that sectors generate per unit of energy that they use is far greater than the variation in the efficiency with which they use the energy[vi]. This may indicate significant additional opportunities to ensure that more economic value is generated from each unit of energy consumed in UK manufacturing.

For example, a haulage company might have trucks with drivetrains that are 5% more energy efficient than a competitor, but if the competitor uses better optimised routes or load scheduling then the energy that they use in order to deliver the same quantity of goods may be far lower. Additionally, by more precisely satisfying the actual needs of their customers (e.g. a confidence that products will be delivered in good condition by a certain date) it may be possible to present even greater value for a given energy use. Alternatively, a resource efficient building design might save 20% of the materials that would otherwise be required in a functionally identical building but through better understanding of the need that the building is to satisfy, an alternative might be designed with even lower embodied energy but offering the same value. In each example, these significant, additional, potential energy savings are outside the scope of energy efficiency or traditional resource efficiency approaches; they relate not to how much is "done" or "produced" (even in a resource and energy efficient manner) but rather the way in which this satisfies the need for which it is purchased.

The wide range of energy productivity values observed and the fact that variation in energy efficiency does not entirely explain it[vii], strongly suggests that there remains significant potential to save energy though better matching between the products and services produced and the needs that they actually satisfy.



**MJ of "Useful exergy"; i.e. controlling for the quality of energy and the energy efficiency with which it is used.*

Figure 3. Variation in economic value generated per unit of energy

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References

[i] Cooper, S. J. G., Giesekam, J., Hammond, G. P., Norman, J. B., Owen, A., Rogers, J. G., & Scott, K. (2017). Thermodynamic insights and assessment of the "circular economy." Journal of Cleaner Production, 162, 1356-1367.

This analysis considered a broad range of over 70 resource efficiency / circular economy approaches reported on in the literature. The full supply chain effect of these approaches was modelled using the Exiobase Multi-Regional Input-Output Database. Direct but not indirect rebound was therefore captured. The results are sensitive to the level of adoption of the approaches that could be achieved but those presented are considered reasonable. Additional resource efficiency approaches are likely to be available – both those missed during the literature review or yet to be envisioned.

[ii] Norman JB; Serrenho A; Cooper SJG; Owen A; Sakai M; Scott K; Brockway PE; Cooper S; Giesekam J; Salvia G; Cullen JM; Cooper T; Barrett JR; Hammond G; Allwood J (2016) A whole system analysis of how industrial energy and material demand reduction can contribute to a low carbon future for the UK.

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[iii] Griffin, P. W., Hammond, G. P., & Norman, J. B. (2016). Industrial energy use and carbon emissions reduction: a UK perspective. Wiley Interdisciplinary Reviews: Energy and Environment, 5(6), 684–714.

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Norman, J. B. (2017). Measuring improvements in industrial energy efficiency: A decomposition analysis applied to the UK. Energy, 137, 1144-1151.

[iv] "Embodied" impacts such as energy use are those that occur due to the supply of that product or service, even if not directly caused by it.

[v] Of course, achieving these improvements might not be equally possible. The actual impacts of each should be considered. In a sense, this reflects the way that the Reduce-Reuse-Recycle maxim is generally but not universally applicable.

[vi] Cooper, S. J. G., Hammond, G. P., & Norman, J. B. (2017). An empirical assessment of sector-level exergy analysis. Energy Procedia, 142, 4050–4055.

[vii] There are many reasons for variations in reported energy productivity. Some are statistical artefacts and others are hard to avoid (e.g. national infrastructure, different products from "same" sector). Variations in energy efficiency are also significant. The adoption of certain resource efficiency measures (e.g. increasing the longevity and intensity of use of products) may also contribute some of the variations. However, there are many other factors that offer the scope for improvements. Even if an improvement in products' values relates to aesthetics (i.e. with no apparent improvement in utility), if that improvement causes a shift in consumption towards goods with a higher energy productivity then the result will be lower overall energy use for a given sized economy.

CIE-MAP

Working closely with government and industry, CIE-MAP conducts research to identify all the opportunities along the product supply chain that ultimately deliver a reduction in industrial energy use.

CIE-MAP brings together the four leading UK universities of Bath, Cardiff, Leeds and Nottingham Trent with a range of expertise in engineering, economics, psychology, design, political science and governance. This work was supported by the Research Councils UK (RCUK) Energy Programme's funding for the Centre for Industrial Energy, Materials and Products (CIE-MAP), grant reference EP/N022645/1.

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